H. Choset Spring, 2002

ME 24-354: General Robotics
Final Exam

Date Handed Out: May 5, 2002
Time Allotted: 1 hour and 30 minutes

- Please show all work.
- You may use one crib sheet.
- You must attempt all problems.
- GOOD LUCK!!!

P1. [***D-H Notation, 20pts***] Consider the following four degree-of-freedom manipulator with one prismatic (linear translation) joint, followed by a prismatic (linear translation) joint that is perpendicular to the previous one, and then two revolute joints (Figure 1).

(a) [***5pts***] Baring joint limits, can this robot arbitrarily position and orient an object in the plane? Why.

(b) [***15pts***] Write out the Dennavit-Hartenburg parameters and variables for this robot. Circle the variables.

P2. [***Two-link Manipulator Path Planning, 25pts***] Consider the follow two-link manipulator in its work space along side its configuration space. The range of motion for each joint is 0^o to 259.99^o, i.e., the robot has joint limits.

(a) [***5pts***] How many degrees of freedom does the robot have?

(b) [***5pts***] Write out the definition of L^1 and L^2 metric and state a reason as to why one is better than the other.

(c) [***10pts***] Using the wave front planner based on the better metric chosen in the previous sub-problem, find the shortest path from the start to goal configuration

(d) [***5pts***] Draw five intermediate configurations between the start and goal configurations, not including the start and goal

P3. [***5pts***] A mobile robot has a planar two-link manipulator, where link 1 is 3 units and link 2 is 2 units in length. List and define the variables that describe the configuration space for this robot.

P4. [***Inverse Kinematics, 30pts***] Consider the two-link manipulator in Figure 4 whose base can slide in a track of length L.

(a) [***2pts***] Write out the variable specifying this robot.

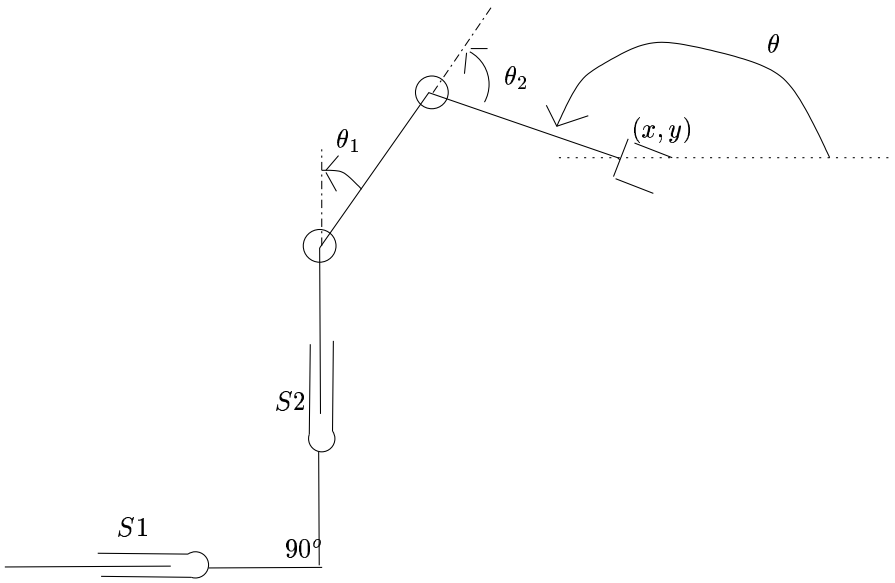

Figure 1. D-H Notation Question

(b) [***8pts***] Assume that $l_2 < l_1$, draw in your blue book the workspace of this robot.

(c) [***20pts***] Determine the joint variables that reach a given x, y in the workspace of the robot.

P5. [***Non-holonomic Planning, 20pts***] Consider the differentially driven cart in Figure 5 that has two independently driven wheels.

(a) [***5pts***] How many degrees of freedom does the cart have in the plane?

(b) [***5pts***] What is the non-holonomic constraint for the cart (i.e., determine the w) and what does it mean.

(c) [***5pts***] What are the initial allowable motions (i.e., determine the g's from the w) and what do they mean

(d) [***5pts***] Can the cart arbitrarily position and orient itself in the plane? Use Lie Brackets to show this.

P6. [***Overview, 5pts***] Robotics can be broken down into various classes of sub-categories. Pick three sub-categories that together encompass the robotics field and then define them.

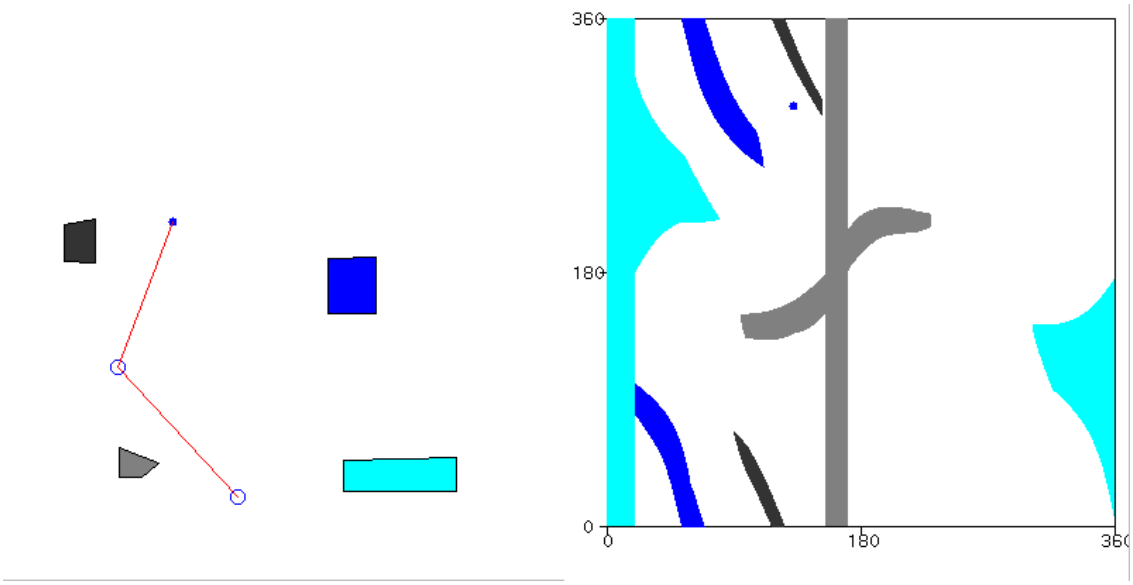

Figure 2. Start Configuration.

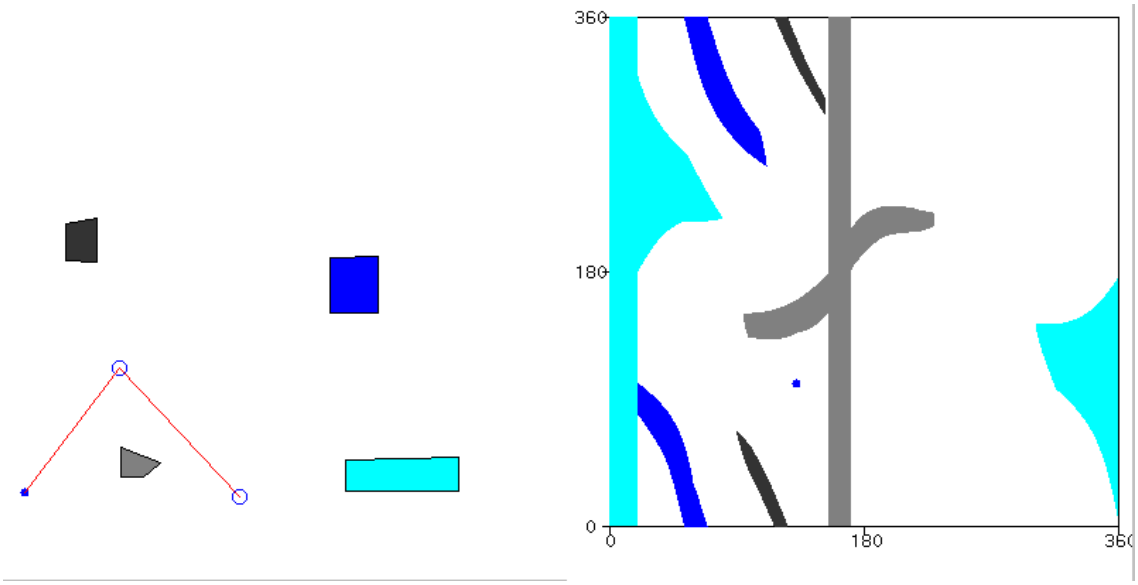

Figure 3. Goal Configuration.

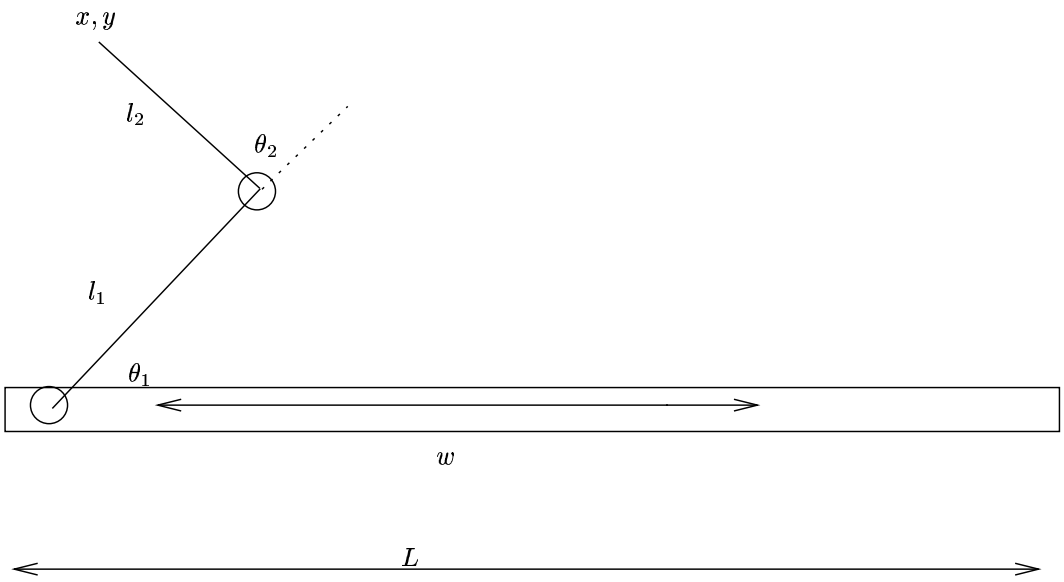

Figure 4. Two-link manipulator in a track.

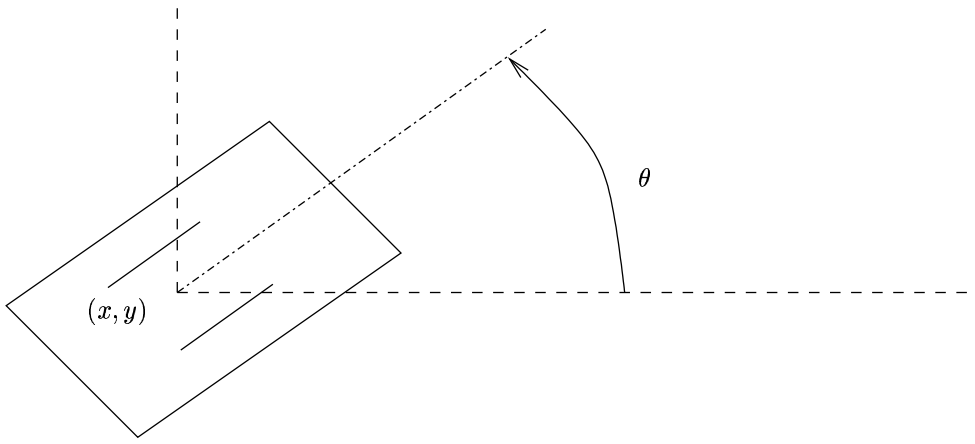

Figure 5. Cart.